Vegetation response of a Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) community to 6 mechanical treatments in Rich County, Utah

Prospectus of Research

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INTRODUCTION

Big sagebrush (*Artemisia tridentata* Nutt.) plays a critical role on rangelands as it occupies 60 million ha in western North America (Beetle 1960). The intermountain sagebrush steppe ecosystem covers 44.8 million ha, and of this total, 1.1 million ha are found in northern Utah (West 1983b). Additionally, the Great Basin-Colorado Plateau sagebrush semi-desert ecosystems occupy 17.9 million ha (West 1983a). In pristine conditions, the intermountain sagebrush steppe is usually typified by a co-dominance of sagebrush and bunchgrasses. The Great Basin-Colorado Plateau sagebrush semi-desert ecosystems, which border the sagebrush steppe to the south, have much less grass (West 1983b).

Sagebrush ecosystems provide important food and cover requirements, as well as breeding and rearing areas for many animal species. Some animals inhabit sagebrush zones only for seasonal use, while others occupy sagebrush communities year-round. Some species have obligate associations with sagebrush for survival, while others are facultative and can adapt to other plant communities and habitats (McAdoo and Klebenow 1979).

Sagebrush rangelands in western North America were undoubtedly altered by the introduction of domestic livestock during the last half of the nineteenth century. After 25 years of expansive livestock production, the sagebrush-grassland ranges with the highest potential were gone. Native perennial grasses were greatly reduced on most sagebrush-grasslands. Big sagebrush and other shrubs increased in density as grasses were removed from communities (Young et al. 1979).

It is believed that vegetation communities of the intermountain west currently dominated by big sagebrush were once dominated by grasses such as wheatgrasses (*Apropyron* spp.) and Great Basin wildrye (*Elymus cinereus*). The degree of grass or brush dominance is very difficult to tell by early records and journals. Stewart (1941) emphasized the abundance of grasses, while Vale (1975) depicted mostly shrub dominance. According to Hull and Hull (1974), Cache Valley in Utah and Idaho was historically dominated by grasslands.

Rehabilitation of degraded sagebrush lands started in the 1930's and increased after World War II. Degraded sagebrush stands were plowed and seeded to introduced grasses such as the drought tolerant crested wheatgrass (*Agropyron cristatum*). After range improvements began, forage production increased for the first time since 1860 (Young et al. 1979).

The era of shrub control and range improvement began with the overabundance of shrubs in areas once occupied by grasslands and/or a mixture of shrubs-grasslands. Many of these areas still had enough of a grass component that the reduction of sagebrush was desired to release the understory vegetation. The major use of herbicides to control sagebrush was initiated by the discovery of the herbicide 2, 4-D. Following the discovery of 2,4-D, sagebrush control became widely practiced (Young et al. 1979). Many range scientists devoted entire careers to sagebrush control. Although mechanical and burning treatments were also used for sagebrush control, much less attention was given to these methods in comparison to herbicides.

The majority of early research on sagebrush control was directed toward eradication for livestock production, while little work focused on sagebrush thinning to improve wildlife habitat. In recent years however, the importance of sagebrush to the ecosystem has been recognized. As a result, sagebrush restoration efforts to benefit wildlife species are becoming more common. In order to accomplish this, a variety of treatment methods need to be studied and evaluated. The purpose of this study is to examine the effects of 6 mechanical treatments on a Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) community in northern Utah. The first objective of this study is to determine shrub response to treatment by comparing sagebrush density, canopy cover, seed production, annual growth, and vigor before and after treatment. The second objective is to understand the effects of each treatment on understory species abundance. This will be done by monitoring release of native understory plants and the establishment of seeded species following treatment.

LITERATURE REVIEW

Range managers had few options to deal with increased shrub densities until the late 1930's when power sources for treatments became available. Herbicide treatments can be useful on ranges that still have a healthy understory component (Pechanec et al. 1965). The herbicide 2, 4-D was discovered in 1942 and was used on rangelands to control big sagebrush. Early experiments focused on finding herbicide rates that were effective in killing big sagebrush, and many studies have shown the effectiveness of 2, 4-D in killing sagebrush (Evans et al. 1979). Cornelius and Graham (1951) killed 85 percent of big sagebrush applying 1 pound of 2, 4-D butyl ester per acre in California. In Wyoming, Hull and Vaughn (1951) and Hull et al. (1952) reported a 75 percent kill using 2 pounds of 2,4-D isopropyl ester per acre, which allowed grass production to double or triple. Hyder (1953) obtained about 85 percent kill of sagebrush in eastern Oregon using 3 pounds per acre of 2,4-D butyl ester.

Problems associated with 2, 4-D have also been studied. 2, 4-D has been shown to be detrimental on forbs (Hurd 1955). Blaisdell and Mueggler (1956) reported that 1/3 of the forbs commonly associated with big sagebrush in eastern Idaho were moderately or severely damaged. Mueggler and Blaisdell (1958) showed that forbs decreased in a 2, 4-D treatment but increased in burned, rotobeaten, and railed areas after the first year, although grass production was much higher in the sprayed treatment than any of the other 3 treatments. Increased production of herbaceous plants is usually short term. Johnson (1969) reported that increased herbage production was nullified within 6 years after spraying due to reinvasion of sagebrush. Conversely, Thilenius and Brown (1974) found that 10 years after spraying, canopy coverage of big sagebrush was 8-42% of pretreatment levels and herbage production was below pretreatment levels. They concluded that increased herbage is a short lived phenomenon and that declines in production were not a result of sagebrush reinvasion. Johnson (1958, 1969) found reinvasion of sagebrush to be slower in ungrazed areas than in grazed areas. According to Johnson and Payne (1968), the major cause of sagebrush reinvasion is surviving plants that provide a seed source.

Although sagebrush spraying may be beneficial to livestock, this method has been shown to be detrimental to sage grouse (*Centrocercus urophasianus*) populations. Klebenow (1970) showed that sprayed areas were not used by grouse for nesting. Sprayed areas may still be suitable for broods, but lower forb amounts are detrimental to young grouse. A decline in cover and food availability following the use of herbicides lowers carrying capacity. Martin (1970) also showed that sage grouse numbers in unsprayed strips were much higher than sprayed strips.

Prescribed burning is a tool that is becoming more common to reduce sagebrush cover while increasing herbaceous production and habitat diversity. Big sagebrush is fire intolerant, and thus is easily killed by fire. The intensity, speed, and temperature of fire is not a factor in how much sagebrush is killed. If a fire front passes through a big sagebrush stand, the stand will be killed. The difficulty with burning is having enough fuel to carry a fire. Wyoming big sagebrush is the most difficult subspecies of big sagebrush to burn because these communities usually have less canopy cover and less of an herbaceous component (Britton and Clark 1985). The effect of fire on grasses and forbs depends on season of burn, size of plant, growth form, species, and precipitation. Fires can enhance growth of perennial grasses but can also promote cheatgrass (*Bromus tectorum*). Many forbs are fire tolerant when burned in the spring or fall. Fire can enhance the number and diversity of forbs because they have hard seed that can be scarified by fire (Wright 1985).

Recovery of sagebrush after burning depends on many factors such as grazing management, weather variables, and subspecies of big sagebrush (Harniss and Murray 1973). Blaisdell (1953) reported that only 10% of sagebrush returned after 12 years in an Idaho mountain big sagebrush stand (*Artemisia tridentata* ssp. *vaseyana*). After 30 years, sagebrush returned to the preburn condition (Harniss and Murray 1973). In a comparison of 4 treatments (burning, rotobeating, spraying, and plowing) on Wyoming big sagebrush in Montana (Mueggler and Blaisdell 1958, Wambolt and Payne 1986, and Watts and Wambolt 1996), it was found that burning had the longest influence on sagebrush cover. Eighteen years after the treatments sagebrush re-establishment was significantly lower in the burn than the other treatments. Perennial grass production was also greatest in the burned area (Wambolt and Payne 1986).

Mechanical treatments come in a wide variety of forms such as plows or disks, pipe harrows, cutters, rails, cables, and chains. Each method varies in its ability to kill sagebrush. Plows and disks cause the greatest disturbance for sagebrush ecosystems because they overturn the soil (Parker 1979). Plows also have the greatest affect on seed bed preparation so this method is valuable when seeding needs to be done. Disks are more effective on ground with little rock. Seventy to 99 % of big sagebrush can be killed with the use of disks or plows (Pechanec et al. 1965).

Harrows, sometimes called a “Dixie” harrow, are used to remove brittle sagebrush on rocky lands. Harrows kill 20 to 70 % of sagebrush, with smaller, younger plants surviving (Parker 1979). Seeding is usually done before the harrow passes. Harrowing once is enough to cover seed and harrowing twice will increase sagebrush kill (Pechanec et al. 1965).

Chaining is a rapid method to reduce competition of big sagebrush and is useful if thinning rather than eradication is desired. Many lower forms of sagebrush are passed over while larger, brittle, decadent plants are removed. Kill of sagebrush varies according to the size of the chain and the type of sagebrush being treated. Chaining more than once increases mortality. Seeding is done by broadcasting before the chain has passed over. This method can be adapted to a wide range of terrain conditions (Pechanec et al. 1965, Parker 1979).

Mowing, cutting, beating, or shredding implements have also been used. These machines cut and shred the woody and herbaceous top growth and leave litter on the soil surface. This method works well on uniform stands of sagebrush where rocks are absent. Large, old plants are killed while younger plants survive. These mechanical implements are useful where release of native understory is desired (Pechanec et al. 1965).

Pechanec et al. (1965) also notes the use of a heavy rolling brush cutter. This machine rolls over sagebrush crushing larger and older plants, while leaving younger plants. This is similar to the pasture aerator to be used in this study.

Wambolt and Payne (1986) noted that rotocutting and spraying maintained similar canopy cover during 18 years of comparison. Plowing left scattered mature plants which provided seed for re-establishment of sagebrush. Reduced competition and favorable seedbed preparation allowed sagebrush in this treatment to have significantly higher canopy cover than any other treatment by the second year after treatment. The plowed treatment had the greatest production of annual and perennial forbs throughout the study period.

Watts and Wambolt (1996) reported in the same study that sagebrush treated by plowing recovered to the level of the untreated control plots in approximately 10 years. Rotocutting and spraying took 18 years to recover. Burned plots were not expected to recover to pre-treatment levels.

Fairchild (1990) reported 1-way and 2-way chained treatments had a positive effect on the age-class composition of a decadent Wyoming big sagebrush stand. Chaining in one direction, with an unmodified (smooth) chain, was shown to be an effective treatment for thinning a decadent sagebrush stand without reducing carrying capacity for wintering mule deer (*Odocoileus hemionus*). Two-way chaining may be more effective in establishing seeded species, but negatively impacts short-term carrying capacity of mule deer. According to Fairchild (1990), restoring understory species diversity while maintaining sagebrush as a dominant species should be a management goal for depleted sagebrush stands.

STUDY SITE

The study site is located in Rich County, Utah on private land owned by Deseret Land & Livestock and public lands managed by the Bureau of Land Management. Neponset Reservoir is located about 2.5 km north of the study site. The vegetation is a homogenous stand of Wyoming big sagebrush at an elevation of 2,000 m. This area is utilized by pronghorn (*Antilocapra* *americana*), mule deer, elk (*Cervus elaphus*), and sage grouse during different periods of the year. Domestic livestock have also grazed the area for a short time as part of Deseret Land & Livestock's grazing system. However, cattle grazing has been excluded from the study site during the duration of this experiment.

METHODS

Experimental Design

In October 2001 and April 2002, 6 mechanical treatments were used to manipulate Wyoming big sagebrush at the study site. These are: 1) disk plow followed by a land imprinter, 2) 1-way chaining using an Ely chain, 3) 1-way pipe harrow, 4) 2-way pipe harrow, 5) meadow aerator (fall), and 6) meadow aerator (spring). Control areas without mechanical manipulation were also used for comparison purposes. The study was designed as a randomized complete block with 3 replications. Each block was divided into 7 plots with treatments being randomly assigned within each block. This yielded a total of 21 plots including the 3 control plots. Each treatment is a 1.1 ha strip (61 m by 183 m) surrounded by a 15 m buffer of untreated sagebrush. The blocks were separated by 40 m strips to allow adequate space for equipment to move from plot to plot.

Revegetation

Revegetation of each plot was done by seeding each treatment with a mixture of native and introduced grasses and forbs. Four wing saltbush (*Atriplex canescens*) was the only shrub added to the mix. The same seed mix and seeding rate was used on each plot. Seed was applied using a broadcast seeder mounted on the back of a tractor. The seeding took place prior to the treatments with the exception of the disk plow and land imprinter. Seed on the disk treatment was applied using a seed box on the imprinter which dropped seed right in front of the imprinter after the soil had been disked. The other treatments were seeded with the broadcaster before treatments except the 2-way pipe harrow treatment where seeding was done between after the first pass and before the second pass of the harrow.

Species	**PLS kg/ha**
Bluebunch wheatgrass	0.6
Hycrest	0.6
Intermediate wheatgrass	1.0
Newhy	1.0
Orchard grass - Paiute	1.3
Russian wildrye - Bozoisky	1.2
Smooth brome	2.0
Thickspike wheatgrass - Bannock	0.3
Alfalfa - Ladek	2.6
American Vetch	0.4
Blue flax	0.5
Rocky Mtn penstemon	0.1
Sainfoin	2.3
Small Burnett - Delar	2.4
Western Yarrow	0.4
Yellow sweet clover	0.9
Fourwing saltbush	0.7
Total	**18.3**

Vegetation Sampling

Pre-treatment vegetation sampling was conducted during the summer of 2001. Post-treatment sampling will be done in the same manner in 2002 and 2003. Each treatment is sampled using a permanently marked 150 m transect divided into 5, 30 m baseline transects. One 30 m cross transect was placed perpendicularly on each baseline transect at a random number along the baseline transect. Twenty evenly spaced 0.25 m^2 quadrats are read on the same side of each 30 m cross transect. Aerial cover, nested frequency, and density values are estimated for all species occurring within a quadrat, including annual species. Cover and nested frequency values are also determined for total vegetation, litter, rock, pavement, cryptogams, and bare ground within each quadrat.

Cover is determined using a slightly modified Daubenmire (1959) cover class method (Bailey and Poulton, 1968). The 7 cover classes are: 1) .01-1%, 2) 1.1-5%, 3) 5.1-25%, 4) 25.1-50%, 5) 50.1-75%, 6) 75.1-95%, 7) 95.1-100%. To estimate vegetation cover with this method, an observer would visualize which cover class all the vegetation would fit into if the plants were moved together until they were touching. To quantify percent cover for bare ground, litter, rock, pavement, and cryptogams, the observer would visually estimate which cover class could accommodate all of the specified cover type within the quadrat. These numbers are then recorded. To determine percent cover for each treatment, the midpoint for each cover class value observed is summed and divided by the number of sampling quadrats (100 per treatment).

Cover of shrubs is estimated using the line intercept method (Bonham 1989). The distance along each cross transect covered by a particular species of shrub is summed and divided by the total length of the cross transects (150 m) to give percent cover.

Nested frequency values for the quadrat range from 1-5 according to which area or which sub-quadrat (nested quadrat) the plant species is rooted in. The notation for each sub-quadrat is as follows: 5 = 1% of the area, 4 = 5% of the area, 3 = 25% of the area, 2 = 50% of the area, and 1 = the remainder of the quadrat. Each time a particular plant species or cover type occurs within a quadrat, it is scored relative to which of the smallest nested quadrats it is rooted in (in the case of vegetation) or where it first occurs (for all other cover types). The highest possible score is 5 for each quadrat occurrence, for a possible score of 500 for each species or cover type at a given treatment. Density of each species is also recorded in each quadrat for a measurement of survival over time.

Shrub densities are estimated using five, 0.004 ha strips centered over the length of each 30 m cross transect. All shrubs rooted within each strip are counted and placed into 1 of 5 classes: seedling, young, mature, decadent, or dead (U.S. Department of Interior Bureau of Land Management 1996). Shrubs are also classified by amount of use and given a vigor class as used in the modified Cole browse method (Cole 1963). Each mature shrub species closest to every 10 foot mark along a sampling belt is measured to determine average height and crown. This allows a possible sample of 50 plants per species per plot, depending on their respective densities.

Estimates of annual leader growth, seed stalk length, and the number of seed stalks per shrub were determined from shrubs selected along the baseline transect. Samples were taken at each of the 6 posts of the baseline transect. The nearest mature shrub to the post in each of four quarters around the post are selected. This yields a sample of 24 shrubs per plot.

Leader length samples were taken by randomly selecting 5 leaders per shrub and measuring each one to the nearest centimeter. Leader length average was taken by measuring from the beginning of the current years' leader growth to the end of the outermost leaf extending past the end of the stem. A total of 120 leader measurements were taken per plot to obtain mean leader length.

The seed stalks of each sampled plant were counted to determine the average number of stalks per plant. From the same plant, 5 seed stalks were randomly selected and measured to determine mean seed stalk length. If there were only 5 or less than 5 all seed stalks were measured (Fairchild, 1990).

Horizontal obscurity will be monitored along each baseline transect to determine the effect of each treatment on this parameter. Horizontal obscurity is the habitat characteristic that has the greatest influence on sage grouse predation (Gregg 1991, Gregg et al. 1994, and DeLong et al. 1995). Horizontal obscurity is measured at 4 of the baseline posts to compare pre-treatment and post-treatment differences. This is quantified using a 1 m^2 cover board stratified into thirds (0-33.3 cm, 33.3 cm -66.6 cm, and 66.6 cm -100 cm) along the vertical axis. Each stratification is then divided into 12 equal squares. Horizontal obscurity measurements are then taken from a height of 25-35 cm at 2.5, 5, and 10 meters from the cover board in four directions. If a square is covered by anything it is counted as covered (Bunnell 2000).

Other Sampling

To determine wildlife use patterns on each treatment a permanent swept pellet group transect has been established on each treatment. Each baseline post marks the center of each of 6 117 m^2 circular plots (for a total of 701.4 m^2 per treatment plot). The number of pellet groups for wildlife are recorded in each circular plot. That number is then converted to days use per ha. Each pellet group will be counted and swept clean each spring and fall to measure use on each treatment.

Soil samples will be taken in each treatment plot and analyzed to determine physical and chemical soil properties across the study area.

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